Advances in multicriteria decision support methods for evaluating development scenarios

Vreeker, R.; Nijkamp, P.

2001

document version
Early version, also known as pre-print

Faculteit der Economische Wetenschappen en Econometrie

SERIE RESEARCH MEMORANDA

Advances in Multicriteria Decision Support Methods for Evaluating Development Scenarios; An Application to Thailand

Ron Vreeker
Peter Nijkamp

Research Memorandum 2001-l5

April 2001

vrije Universiteit amsterdam

ADVANCES IN MULTICRITERIA DECISION SUPPORT METHODS FOR EVALUATING DEVELOPMENT SCENARIOS; AN APPLICATION TO THAILAND[1]

23-4-01

Ron Vreeker
Peter Nijkamp

Department of Spatial Economics
Free University Amsterdam
De Boelelaan 1105
1081 HV Amsterdam
The Netherlands
Phone: +31-20-4446088
Fax: +31-20-4446004
Email: rvreeker@econ.vu.nl

vrije Universiteit amsterdam

[1] This paper builds on a previous study published by Nijkamp and Vreeker (2000).

Table of Contents

Abstract

Rational decision-making requires an assessment of all pros and cons of choice possibilities, including non-market effects such as environmental and spatial externalities. In the past decades various decision support and evaluation methods have been developed in which a market evaluation played a prominent role. Gradually, also a variety of adjusted multidimensional evaluation methods has been developed. These methods aim to investigate and evaluate all relevant impacts of a choice set on the basis of a multitude of relevant policy criteria (so-called multicriteria methods).

This paper aims to offer a new perspective for assessing sustainable development strategies at the regional level. This framework is based on a blend of two types of approaches, viz. Regime Analysis (an advanced pair-wise comparison method for discrete choice options) and the Flag Model (based on critical threshold value analysis of outcomes of choice options).

By means of this triangular framework an empirical case study is undertaken for the Songkhla/Hat Yai area in southern Thailand. Based on a multidimensional indicator system for sustainable development, a comprehensive qualitative community impact assessment system and the above mentioned compound evaluation framework, three distinct policy scenarios are systematically evaluated using a combination of the critical threshold value approach (the Flag Model) and the Regime Analysis. The paper is concluded with a few retrospective remarks.

1. Introduction

Evaluation has played a prominent role in many planning studies in the past decades. More recently, the attention has shifted towards sustainability as a planning task.

The sustainability debate is in the mean time more than a decade old. It has generated a wealth of research and policy discussion on the meaning, measurability and feasibility of sustainable development (van Pelt, 1993). Despite some intrinsic ambiguity in the concept of sustainability, it has prompted policy-makers and planners to formulate new strategies for achieving a balanced economic ant technological pathway that would safeguard our environment, not only here and now, but also elsewhere and in the future. It is clear that the problem of 'evaluation in planning' is still an important research issue (see Lichfield et al., 1975), as it positions evaluation at the interface of many decision-making disciplines.

For economists, the notion of sustainable development has meant a new challenge, as they were forced to broaden existing analytical frameworks towards the domain of ecological systems or even international negotiation tables (van den Bergh, 1996). In the debate among economists regarding measures for coping with environmental externalities, the standard therapy for solving market failures, i.e. Pigouvian taxes, has become rather popular in recent years (witness the discussion on eco-taxes, for example). However, others advocate alternative policy approaches such as tradeable permits, standard setting or even prohibitions. In practice, we have seen a portfolio of different policy measures reflecting a compromise between political-economic viewpoints (Finco and Nijkamp, 2001). In most policy and scientific discussions on sustainable development, we observe the need for a broad evaluation of environmental issues, in which economic, social and environmental motives play an intrinsic role, even though the precise balance is not know.

An interesting attempt to focus sustainability research is to address specific sectors or regions. And consequently, we observe a growing interest in research that moves away from global sustainability analysis towards empirical policy-relevant research at the regional and urban level (Giaoutzi and Nijkamp, 1993; Capello et al., 1999). This new interest in regional sustainability analysis is caused by several factors: a region is a properly demarcated area with some degree of homogeneity; this allows researchers to do a more operational empirical investigation. Besides, a region is usually subject to a properly regulated administrative competence and control, so that there is more scope for policy analysis of important sustainability issues. Finally, the statistical data base at a regional level is often appropriate for monitoring, analysing and modelling the economy and ecology of an area (Nijkamp, 1999).

Clearly, the openness of a regional system might create a complication, as externalities may be imported or exported via trade or dispersion of pollution. Consequently, some authors make a distinction between internal and external sustainability, where external sustainability takes also the spillover effects to and from other areas into account (cf. the notion of the ecological footprint; (see Wackemagel and Rees, 1996)). Clearly, seen from this perspective, sustainability is context-specific and may hence be co-determined by needs and opportunities in a given region as part of a broader spatial system.

The previous discussion has pointed out that sustainability – as a policy concept – is not an unambiguous state of affairs, but a multi-faceted phenomenon, fraught with conflicts and uncertainties. As mentioned, the notion of a sustainable city or region comprises a great variety of (sometimes) conflicting dimensions, such as economic, social, land use, ecological and transportation interests, among which a balanced compromise has to be found by policy-makers (Banister, 1999). Conflict resolution is, of course, a political action, but presupposes proper knowledge on the pros and cons of alternative choice possibilities. From an economic perspective this would ideally imply that all foreseeable costs and benefits of a planned initiative would have to be assessed.

In the past several methods have been developed and applied in policy analysis, in which a market evaluation played a prominent role. The most well-known example of such a market evaluation method is based on cost-benefit *analysis* (as an operational application of welfare theory). This method forms the foundation for many policy assessment methods and has formed the economic basis for in many case studies in the public sector.

Cost-benefit analysis has also some severe shortcomings; especially in a situation with intangible aspects, this theoretically elegant method has often limited applicability. In many (public) policy evaluation studies, the assessment of environmental impacts turns out to be troublesome, since all advantages and disadvantages of policy options would have to be translated into a common monetary unit. Hence, incommensurable criteria of an unpriced and intangible nature cannot be included in a decision-making procedure based on a standard cost-benefit analysis. Furthermore, in the current policy practice in many countries there is hardly any applicable and meaningful way of including distributional impacts on welfare (e.g., through a weighting system for different groups) into policy evaluation.

As a response to these shortcomings, community impact assessment (or planning balance sheet methods) as advocated by Lichfield et al. (1975) have gained much popularity, as they are able to encapsulate also qualitative and distributional aspects. The trade-off among different outcomes in case of qualitative outcomes is somewhat troublesome, however.

As a response to the shortcomings of conventional evaluation techniques, a great diversity of modem assessment methods has been developed over the last ten years in order to extend their domain and to provide a complement to conventional cost-benefit studies. The aim is to offer a perspective for procedural types of decision-making in which various quality aspects are also incorporated. Many of these methods simultaneously investigate the impacts of policy strategies on a multitude of relevant criteria, partly monetary, partly non-monetary (including qualitative facets). They are often coned *multicriteria methods* and are also known as multi-assessment methods. This approach derives its strength from the fact that it is, in principle, able to handle qualitative, quantitative and mixed data on distinct choice possibilities in decision-making.

The present paper aims to offer a new methodological framework that is fairly general in nature and may in principle be used for a variety of case studies on spatial sustainability. The paper is organised as follows. Section 2 of the paper offers some specific methodological

reflections on sustainability analysis and a presentation of an operational framework for assessing sustainable development at the regional level. Section 3 is dedicated to a discussion of the evaluation methods included in our methodology. It takes a closer look at the principles of this methodology by means of a more detailed description of the Flag Model and the Regime Analysis. The preceding section (Section 4) is concerned with a case study on the Songkhla/Hat Yai area in Southern Thailand. After a concise description of the natural and regional economic development problems in this area, the methodology and the evaluation techniques are applied and clarified in Section 5 and Section 6. In section 7 we draw conclusions and offer some further reflections.

2. A Decision Support Methodology for Regional Sustainability Assessment

The notion of sustainability has become fashionable in modem planning. Sustainable development can be defined in numerous ways (Pezzey, 1989). In this paper we will adopt the simple view that sustainability means that the development of an economy (national, regional) has to take place within a set of pre-specified normative constraints or pathways. According to van Pelt et al. (1992, 1994) a sustainability constraint has at least four attributes: (i), it is expressed in one or more measurable parameters; (ii), these parameters are linked to sustainability targets; (iii), the parameters have a proper geographical scale; (iv), these parameters have also a relevant time dimension. Ideally, such constraints should be mapped out in a quantitative way, but in reality we are often confronted with qualitative, fuzzy and incomplete information. In general, there may be various ways to identify such constraints (e.g. safe minimum standards, quality standards, carrying capacity, ecocapacity, maximum sustainable yield, critical loads, vulnerability (or fragility), environmental utilisation space, etc.). All such concepts may, in principle, be useful for a policy analysis. We will in our approach encapsulate such normative policy statements under the general heading of critical threshold values (Nijkamp and Ouwersloot, 1998). These values will form an important ingredient in our decision support model.

In the regional sustainability assessment presented here, we will distinguish the following steps (see Figure 1). Clearly, various feedback mechanisms and/or iterative steps may also be included in this stepwise approach. It goes without saying that the simplified and schematic general framework depicted in Figure 1 is fraught with various difficulties of a theoretical/methodological and empirical/policy nature (Bithas et al., 1997). Case study research is necessary to test the framework on its scientific merits and policy relevance. To obtain a proper level of information for a sustainability test in the various steps of a policy process is, of course, a major challenge.

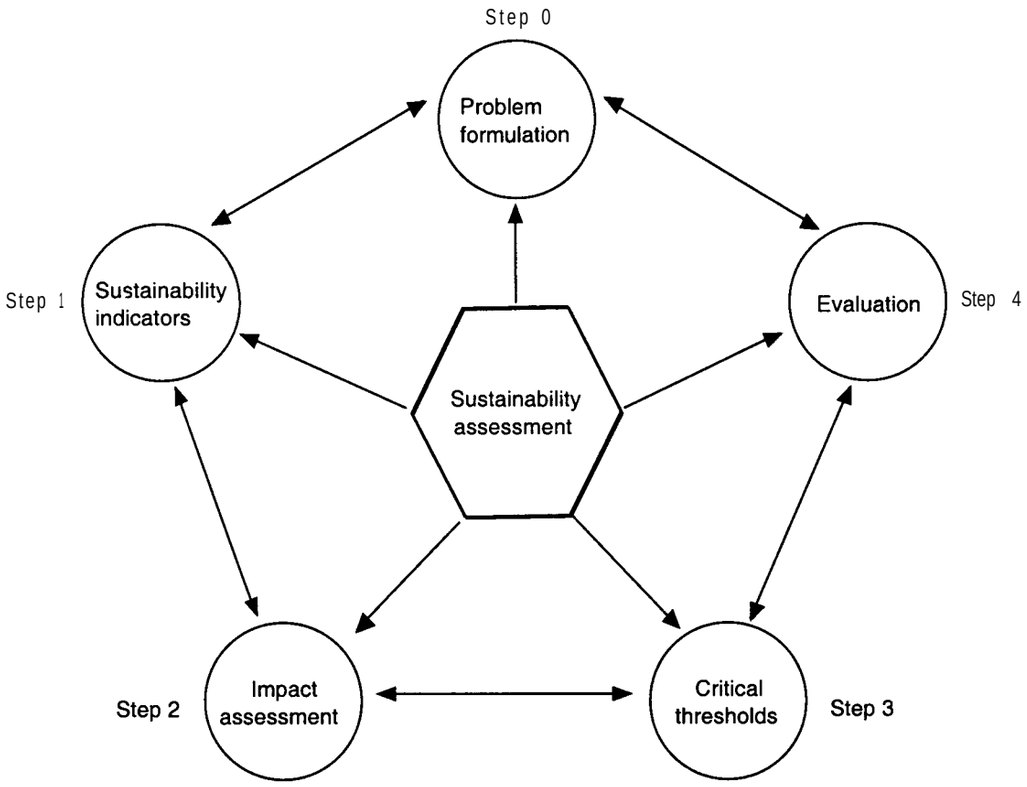


Figure 1. Steps in a sustainability assessment procedure

3. The Evaluation Framework: a Description

The designed framework is based on a joint use of various multicriteria methods. The core of the methodology is formed by the Flag Model, extended with complementary methods, viz. the Regime Analysis. Since the critical threshold value approach is central in this paper, on sustainability planning, we will start with a presentation of the so-called Flag Model.

3.1 The Flag Model

The main purpose of the Flag Model is to analyse whether one or more policy alternatives can be classified as acceptable or not in the light of an *a priori* set of sustainability constraints. The model does so by comparing impact values with a set of normative reference values (critical threshold values). We will in particular adhere to the description of RMNO (1994) that *"sustainable development implies that the environmental impact of human activities stays well within limits of how much environmental impact the biosphere can take"*. The specification of such limits provides a testable framework for policy decisions.

In this context the notion of 'environmental utilisation space' offers an interesting and useful orientation, as it refers to the amount of environmental pressure or resource depletion a life support system can bear on both economic and ecological grounds. The environmental utilisation space takes for granted that the environment has some regenerative capacity, so that also a distinction between renewable and non-renewable resources can be made.

Clearly, one needs to define and specify meaningful and measurable indicators for sustainable development. There are no general and unambiguous sustainability indicators;

they are always context- and site-specific. Taking for granted the existence of a set of such indicators, after careful field research, a critical threshold value (CTV) for sustainable development is then defined as the numerical normative value of a sustainability indicator. This normative value (at the margin) ensures a compliance with the carrying capacity of the regional environmental system concerned. Violation of a CTV means unacceptably high social costs to the environment or the socio-economic system concerned. Clearly, such a CTV may originate from the above-mentioned concept of environmental utilisation space, critical loads, carrying capacity, sustainable yield, etc. (Weterings and Opschoor, 1994). It should be added that the introduction of such normative values is not entirely new in environmental management. Since the path-breaking contribution of Ciriacy-Wantrup (1952) on resource conservation, there has been an ongoing flow of scientific contributions on the use of such normative standards. What is novel here is that the CTV approach is cast in the framework of a decision support approach.

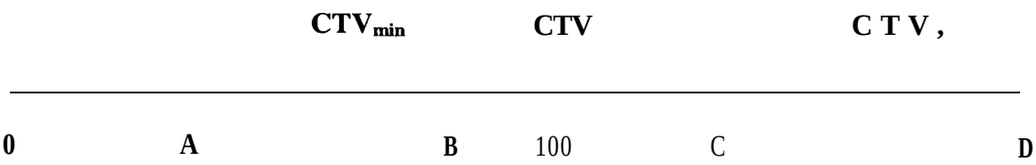
It is, of course, an interesting question how a CTV can be assessed. Clearly, it has to be based on solid scientific research concerning, e.g. resource availability or human health effects. This means that scientific information and expert opinion are of critical importance. In additon however, it ought to be recognised that several CTVs have by definition a policy meaning (e.g. in terms of the acceptable level of access to resources), so that there is, of course, a policy involvement in the specification and numerical assessment of CTVs.

Thus the concept of CTVs must be used with great caution. It is based on existing knowledge that may be specific for a given area, for local socio-economic and natural conditions, and for local particular local/regional policy ramifications. Furthermore, some changes in natural conditions may exhibit a resilience, so that after a temporary time period of violating critical threshold conditions a return to a sustainable development or an environmental security pathway may take place.

Clearly, for each sustainability or security indicator – be it environmental or socio-economic – a separate CTV has to be determined, so that the entire set of CTVs may act as a reference system for judging actual states or future outcomes of scenario experiments. If, for example, an indicator has cost meaning (in other words, 'a lower value is better'), then a level above the CTV signifies a dangerous or threatening development that is in a strict sense unacceptable. Clearly, a value of a sustainability or security indicator that is lower than the CTV is, in principle, acceptable or desirable. The inverse reasoning applies to benefit indicators. We will use here in our interpretative analysis – for the sake of simplicity – only cost indicators, as benefit indicators can easily be transformed into cost indicators.

A major problem faced in practice is thus the fact that the CTV level is not always scientifically unambiguous. In certain areas and under certain circumstances, different experts and decision-makers may have different views on the precise level of a CTV. It may even happen that a CTV is fuzzy in nature, so that then fuzzy assessment methods have to be used (Munda, 1995). A relatively simple and manageable approach to the above mentioned uncertainty problem is to introduce a bandwidth for the corresponding value of the CTV, defined as CTV_{min} and CTV_{max}, respectively. This bandwidth mirrors the minimum and maximum range of CTV values expressed by experts or policy-makers. CTV_{min} indicates a

conservative estimate of the maximum allowable threshold of the corresponding sustainability (min-max condition). CTV_{max} on the other hand refers to the maximum allowable value of the sustainability indicator beyond which an alarming development will certainly start (max-max condition). This can be represented as follows, assuming that the original CTV has an index value of 100:



The line segments can now be interpreted in the following way:

Section **A**	**Green**	no reason for specific concern
Section **B**	**Yellow**	be very alert
Section C	**Red**	reverse trends
Section **D**	**Black**	stop further growth

It should be noted that deviations from the average can also be denoted by ++, +, +/-, -, and --, as will be illustrated later on.

The Flag Model is a visually appealing manner to confront decision-makers with environmental state of affairs in a certain area. It can also be represented in a computerised way by colour graphs or coloured flags. In this way, the basic information for making trade-offs between conflicting objectives in a sustainability assessment is available.

The evaluation of various policy options for sustainable development based on the Flag Model, can be facilitated by utilising a recently developed software programme (SAMI, 2000). This programme analyses the degree to which a choice possibility can optimise multiple objectives like socio-economic progress or environmental quality.

Once the data base and information on the set of CTVs have been collected, one may use policy experiments (scenarios, visioning methods, forecasting techniques, delphi-types of communicative procedures) to generate a series of 'alternative futures' which then may be judged on the basis of a multidimensional set of relevant policy criteria, while taking into account the importance of and existence of CTVs in identifying policy decisions. In this context it is also noteworthy that multicriteria analysis (e.g., Regime Analysis) forms an important complementary analytical tool.

The assessment module of the Flag Model provides a number of instruments for the analysis of alternatives. This analysis can be carried out in two ways. The first option is the inspection of a single alternative. The second one is the comparison of choice options. In the first procedure we decide whether an alternative is acceptable or not. In the latter case of comparing two alternatives, we decide which alternative scores best. This last option may be interpreted as a basic form of multicriteria analysis.

The Flag Model can operate both as a classification procedure and as a visualisation method. In the former case - for example, in combination with Regime Analysis - the Flag

Model can determine the acceptable alternatives; accordingly, the examined alternatives can then be ranked by means of Regime Analysis. In the second place, one of the major merits of the Flag Model is its potential for representation. There are three approaches to such a representation: a qualitative, a quantitative and a hybrid approach.

The qualitative approach only takes into account the colours of the flags. This entails flag counts and cross-tabulation. This approach merely displays in various insightful ways the results obtained from the evaluation. The quantitative approach defines the values of the standards that may be acceptable or not. To achieve such results, we need to standardise the indicator (values), because they refer to different aspects, which are next expressed by different measurement scales. Finally, the hybrid form regards the existence of both qualitative and quantitative aspects.

3.2 Regime Analysis

Multi-criteria analysis comprises various classes of decision-making approaches. The multi-assessment method used in our methodology is Regime Analysis. Regime Analysis is a discrete multi-assessment method suitable to assess projects as well as policies. The strength of Regime Analysis is that it is able to cope with binary, ordinal, categorical and cardinal (ratio and interval scale) data, while the method is also able to use mixed data. This applies to both the effects and the weights in the evaluation of alternatives.

The fundamental framework of the method is based upon two kinds of input data: an impact matrix and a set of (politically determined) weights (see for a detailed exposition Nijkamp et al, 1990 and Hinloopen et al, 1983). The impact matrix is composed of elements that measure the effect of each considered alternative in relation to each policy-relevant criterion. The set of weights incorporates information concerning the relative importance of the criteria in the evaluation. In case there is no prioritisation of criteria in the evaluation process, all criteria will be assigned the same numerical weight value.

Regime Analysis is a discrete multicriteria method, and in particular, it is a generalised form of concordance analysis, based on a generalisation of pair-wise comparison methods. Concordance analysis is an evaluation method in which the basic idea is to rank a set of alternatives by means of their pairwise comparisons in relation to the chosen criteria. We consider a choice problem where we have a set of alternatives i and a set of criteria k. For each criterion a policy weight is assumed to be given. We now need to rank the alternatives. In order to do so, we introduce the concordance index. The concordance index is defined as the sum of the weights that are related to the criteria for which alternative i is better than alternative k. We call this sum C_{ik}. Then we calculate the concordance index for the same alternatives, but by considering the criteria for which k is better than i, i.e., C_{ki}.
After having calculated these two sums, we subtract these two values in order to obtain the net concordance index $\mu_{ik}=C_{ik}-C_{ki}$. Because in most cases we have only ordinal information about the weights (and no trade-offs), our interest is in the sign of the net concordance index of i with respect to k. If the sign is positive, this will indicate that alternative i is more attractive than alternative k; otherwise, the opposite holds.

We are now able to rank our alternatives. We note that due to the ordinal nature of the information in the indicator μ_{ik} no information exists on the size of the difference between the alternatives; it is only the sign of the indicator that matters.

We may also solve the complicating situation that it may not be possible to determine an unambiguous result, i.e. a complete ranking of alternatives, because of the problem of ambiguity in the sign of the index μ. In order to solve this problem we introduce a performance indicator - as a semi-probability measure - p_{ik} for the dominance of criteria i with respect to criteria k as follows:

$$p_{ij} = \textbf{prob} \quad (\mu_{ij} > 0)$$

Next, we define an aggregate probability measure, which represents the success (performance) score as follows:

$$p_i = \frac{1}{I-1} \sum_{j \neq i} p_{ij}$$

where I is the number of chosen alternatives.

The problem here is to assess the value of p_{ij} and of pi. The Regime Analysis then assumes a specific probability distribution of the set of feasible weights. This assumption is based upon the Laplace criterion in the case of decision-making under uncertainty.

In the case of a probability distribution of qualitative information, in principle, the use of stochastic analysis will be sufficient, which is consistent with an originally ordinal data set. This procedure helps to overcome the methodological problems we may encounter by applying a numerical operation on qualitative data.

From the viewpoint of numerical analysis, the Regime method identifies the feasible domain within which feasible values of the weights w_I must fall in order to be compatible with the condition imposed by their probability value. By means of a random generator, numerous values of the weights can be calculated. This allows us at the end to calculate the probability score (or success score) pi for each alternative i. We can then determine an unambiguous solution and rank the alternatives.

Regime Analysis is able to examine both quantitative and cardinal data. In case of choice problems with qualitative data, we first need to transform the qualitative data into cardinal data and then apply the Regime method. The Regime Software method is able to do so consistently[2]. Due to this necessity, Regime Analysis is classified as an indirect method for qualitative data. This is an important positive feature. When we apply the cardinalisation of qualitative data through indirect methods such as the Regime Analysis, we do not lose information like in direct methods. This is due to the fact that in the direct methods only the ordinal content of the available quantitative information is used.

[2] Regime analysis is included in the software package SAMIsoft, a deliverable of the EU project SAMI.

4. Application of the Evaluation Methodology and Methods

4.1 Sketch of the region

Thailand consists of a compact heartland, or mainland, and a long southern peninsular extension of the Malay Peninsula. This has a maximum north-south length of about 800 km. Forest occupies approximately 28% of the land are, while farmland covers approximately 39%. Four topographical regions are distinguished. The most important one is the central region, which occupies almost one-third of the nation and includes the fertile alluvial lowlands of the Chao Phraya river, 'Thailand's rice bowl'. Thailand's three other distinct topgraphical areas are the northern region (a mountainous and forested area), the north-eastern or Khorat Plateau region (an area poorly endowed with resources and with unproductive lateritic soils) and the southern, or peninsular, region on the Malay Peninsula (rich in rubber and tin). Our case study on Songkhla/Hat Yai concerns the latter area.

Songkhla is a city located in the south of Thailand (950 km distance from Bangkok) close to Malaysia. The city is situated on a long and narrow peninsula stretching 9.3 km between the Gulf of Thailand on the east and the Songkhla Lake, a fresh water lagoon, on the west. Songkhla has an urban population of 86000 people within its municipal boundary. Together with Hat Yai, a city of approximately 140,000 inhabitants at 25 km distance to the South, Songkhla serves as the regional center for the South of Thailand. Songkhla is the capital city of the Songkhla Province and is the administrative, educational and cultural center of the region. Hat Yai is the commercial part of both cities. The major commercial activities in Songkhla are related to fishery. The city possesses a big Deep Sea Port for fishing ships. Tourism is another source of income and will likely become more important in the near future. Together with Hat Yai, Songkhla is the third most important destination for foreign tourists in Thailand. The other economic activities in Songkhla are related to government services and activities in the private sector.

Since Hat Yai is also a part of the defined research area, we will give a short description of this influential city. Hat Yai is Southern Thailand's commercial center and one of the Kingdom's largest cities, though it is only a district of Songkhla Province. A steady stream of customers from Malaysia keeps Hat Yai's central business district booming. Hat Yai is very much a Chinese town in its center, although also a substantial Muslim minority is concentrated in certain sections of the city. Since the city shares several common features with Bangkok, Hat Yai is often called "Little Bangkok".

We will give here a concise overview of the main economic activities in this area. In terms of **agriculture,** the region possesses the country's largest rubber plantation fields. About 44 percent of the households in the region are engaged in rubber plantation. Next, **fishery** is an important activity; it is mainly related to the black tiger shrimp culture. Shrimp culture in Songkhla has a high development potential caused by the large suitable area around the coastlines. Furthermore, there are great opportunities for the production of fruits such as oranges, coconuts, limes, flowers and decorative plants, and vegetables for exports.

Traditionally, the **industry** in Songkhla Province consists mainly of agro-industries, or industries and services related to this sector. Relying on indigenous resources including rubber

and fishery, they are mostly labour-intensive. Most industries are located in or near areas equipped with good basic infrastructure like the city of Songkbla and the city of Hat Yai. Most industries profited from the governmental policy to redistribute growth and welfare to the regions. Many investors were encouraged to invest in Songkhla. Industries like para-wood furniture and frozen sea foods expanded, and the international position of some industries improved, influenced by these investments.

Trade and services in Songkhla cover various business branches and industries. This sector has recently started. Songkhla (city) is an important domestic and international market center for consumption commodities. Hat Yai serves as a center for rubber trade in the province and the South of Thailand. Songkhla is an international trade center in the South of Thailand facilitating trading, in particular with Malaysia. Commercial banking and financing has also grown in recent years. There are some opportunities for the province to become a center of trade, finance and marketing in the Indonesia-Malaysia-Thailand triangle (IMT-triangle). The decentralization policy of the Thai government is an important development factor for Songkhla.

Songkhla has diverse **tourist** attractions. They include natural attractions, historical sites, entertainment areas, and various shopping centers. The favourable connections (e.g. the airport) and communication networks with various cities in the neighbouring countries have contributed to the growth of the number of tourists who see Songkhla as a temporary destination. About 60 percent of the tourists are Thai, the remaining ones are foreigners mainly from Asian countries like Malaysia and Singapore. Increasingly more Europeans and people from Australia come to visit the province on their way to Malaysia or Indonesia.

In general, the Thai governmental policy can be summarised under six themes: *decentralisation policies, policies related to agriculture, industrial policies, policies related to tourism, Indonesia-Malaysia-Thailand trade-triangle policies (ZMT-triangle)* and *environmental policies.*

For Songkhla and Hat Yai it is important to take into account the development guidelines set for the Southern Region. The main development guidelines are related to conservation and rehabilitation of natural resources, and the promotion of tourism (Phuket, Samui-Pha Ngan and Ang Thong Islands), investments in infrastructure (communications and transport) and the promotion of coastal cities and border provinces to form a gateway in order to stimulate trade with neighbouring countries. Industrial estate development is promoted to serve industrial requirements, particularly agro-industries, such as rubber, palm oil and sea food. Several regional urban centers in Southern Thailand are supported in order to redistribute development efforts to the region, In the next section we will describe in more detail various sustainability options for the region.

4.2 Design of development scenarios for the Songkhla/Hat Yai region

Key issues in applying the concept of sustainability to Thai areas are the organisation of production and consumption (the socio-economic system), the quantity and quality of environmental functions, and the interaction between the socio-economic and environmental system in the short and long term. An application of the sustainability concept, will of course,

lead to different analytical problems and outcomes depending on location-specific circumstances. This holds especially for the application of the sustainability concept in developing countries. In general, developing countries have other environmental systems than most developed countries. Climatic circumstances and geographic conditions have a distinct impact on the features of ecosystems. Many developing countries possess highly diversified but fragile ecosystems. Moreover, developing countries are still predominantly rural, whereas the developed world is largely urbanised. Socio-economic systems in developing countries also differ from those in developed countries. These location-specific circumstances should be taken into account in the operationalisation of the sustainability concept and the assessment of sustainability in the Sonkhla/Hat Yai area.

In this section of the paper, the policy aspects that are of critical importance for the assessment of sustainable development in the Songkhla/Hat Yai area, will be presented. The three policy scenarios used in the sustainability assessment will also be described in this section. These scenarios are based on the six policies described in the preceding section.

We will now present in a systematic, compact way the three policy scenario's (A,B and C) for the area at hand, that by policy-makers and experts in the area were regarded as meaningful and potentially promising policy packages to be further investigated, viz. the decentralisation scenario, the sectoral and regional development scenario and the environmental protection scenario (see Tables l-3 in the Annex). It should be noted that these scenarios are to be seen as packages comprising policy objectives and measures. In various case the objectives are not always sharply defined, as it was sometimes difficult to get consensus on precisely defined targets.

*4.3 Sustainability assessment **of** the study area*

In this part of the paper the development scenarios mapped out in the Annex will be assessed in terms of their sustainability consequences. In order to evaluate these scenarios, sustainability indicators and the effects these scenarios have on these indicators need to be measured. Therefore, the Songkhla/Hat Yai area is presented as a complex regional system. For this complex system sustainability indicators are identified, while next the consequences of these development scenarios for these sustainability indicators are traced by means of this complex system. The result of this assessment is thus based on a qualitative community impact assessment matrix. We will follow here the successive steps described in Figure 1.

*Step 0: design **of** complex regional system **for** the Songkhla/Hat Yai area*

In this part of our analysis the economic, social and environmental subsystems within the Songkhla/Hat Yai area are identified and represented as a multi-faceted, interlinked system. However, due to lack of quantitative information the complex system of the Songkhla/Hat Yai area will be mapped out in a graphical way by means of graphs and arrows. The design of this system is made in a modular fashion. This means that the main components of the main components of the regional system (economic, social, demographic and environmental) make up the architecture of the system, while next in a systematically nested way the various interlinked sub-components are depicted.

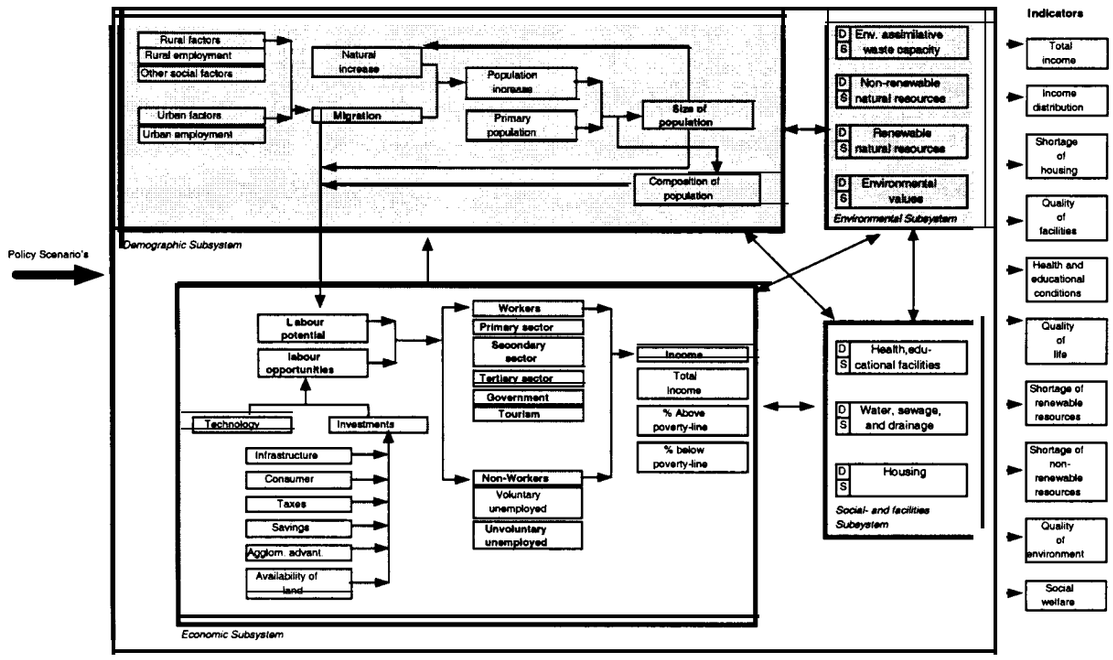


Figure 2: The qualitative complex systems model for the Songkhla/Hat Yai area..

The design of this system for the Songkhla/Hat Yai region is based on extensive fieldwork in close consultation and co-operation with several regional and local experts. The presentation of this complex system can be found in Figure 2. By following a stimulus-response approach it is in principle possible to estimate the implications of distinct policy scenarios for various relevant sustainability indicators, based on the principles of community impact assessment (see Lichfield, 1996).

Step 1: identification of measurable sustainability indicators

By means of systematic fieldwork in the Songkhla/Hat Yai area, a rather extensive data base has been built that offers sufficient insight into the working of the different subsystems and their mutual relationships. In the sustainability analysis, 16 different indicators are used. These indicators show clearly the influence of the various scenarios on the area and are therefore useful for our analysis. With the help of the four subsystems mentioned above, measurable sustainability indicators can be subdivided into four subgroups, namely economic indicators, social indicators, demographic indicators and environmental indicators.

In our empirical research the expected value of the indicators is assessed on the basis of the likely influence a scenario exerts on these indicators. In a purely qualitative sense, two binary possibilities concerning the variables can be used in our approach: a minus sign (-) is used when an increase in the value of the indicator has a negative effect on social welfare; a double minus sign (--) means a very negative effect. A plus sign (+) is used when an increase in the value of the indicator influences social welfare positively. A neutral effect is indicated as a +/-. As mentioned above, the final judgement concerning the impact of scenarios on regional sustainability is undertaken with the help of the CTVs, in particular in terms of the frequency of occurrence of green, yellow, red and black flags (Table 1).

Table I. Sustainability threshold values for indicator ».

Main Criteria	Sub-criteria[3]	CTV min	CTV	CTV max
Economic	Employment primary sector	+/-	-	--
	Employment secondary sector	+/-	-	--
	Employment tertiary sector	+/-	-	--
	Employment government sector	+/-	-	--
	Employment tourism	+/-	-	--
	Involuntary unemployment	+/-	-	--
	Total income	+I-	-	--
	Income distribution	+/-	-	--
Social	Shortage of housing	+/-	-	--
	I Quality of facilities	+/-	-	--
	Health and educational facilities I	+/-	-	--
	Quality of life	+/-	-	--
Environmental	Shortage of renewable resources	+/-	-	--
	Shortage of non renewable resources	+/-	-	--
	Quality of the environment	+/-	-	--
Aggregated	Social sustainability effect	+/-	-	--

Step 2: assembling the impact matrix

After the presentation of the complex regional system and the selection of sustainability indicators, it is now possible to estimate empirically the implications of various policy scenarios. In measuring the effects of a policy scenario has on the sustainability indicators, the impact matrix plays a crucial role. Tracing the consequences of a policy measure step by step through the whole complex system designed can pursue this. It is important to note that a distinction can be made between first-, second-, third- and higher-order effects. These influences determine the overall effect a scenario has on the indicator concerned. All effects are standardised, and each possible effect can be described by qualitative symbols (++, +, +/-, - or --). Several of these qualitative expressions have an underlying quantitative value, but for the sake of uniformity we will present all effect values in qualitative terms.

These empirically based values will be deployed in the final assessment with the help of the Flag Model and Regime Analysis. By means of a recently developed software programme the values will be compared with a set of a priori formulated CTVs (see Table 1). Clearly, each scenario A, B and C has different effects. A short description of the effects of each separate scenario on the indicators will be given now, where the assessment is largely based on expert opinion in the area under study.

[3] All criteria are benefit indicators and measured on a qualitative scale.

Table 2. The impact matrix for alternative regional development plans.

	Criterion	A	B	C
Economic	Employment primary sector (+)	+	+/-	+/-
	Employment secondary sector (+)	+/-	+	+/-
	Employment tertiary sector (+)	+	+	+/-
	Employment government sector (+)	+/-	+/-	+/-
	Employment tourism (+)	+/-	+/-	+/-
	Involuntary unemployment (+)	--	--	+/-
	Total income (+)	++	+	+/-
	Income distribution (+)	--	-	+/-
Social	Shortage of housing (-)	+/-	+/-	+/-
	Quality of facilities (+)	+/-	-	+/-
	Health and educational facilities (+)	+/-	+/-	+
	Quality of life (+)	+/-	-	+/-
Environment	Shortage of renewable resources (-)	+	+/-	+
	Shortage of non renewable resources (-)	+	+/-	-
	Quality of environment (+)	+/-	+/-	+
	Social welfare (+)	+/-	+/-	+/-

Step 3: Specification of CTVs for sustainability

It is clear that the establishment of CTVs is not immediately straightforward. In our case, there was not direct and sufficient expert knowledge available. Therefore, as part of the policy strategy assessment we decided to introduce three virtual visions that may function as three options for establishing a CTV, which might generate a variation around an average value in terms of CTV_{min} and CTV_{max}. Thus, three auxiliary visions on CTVs are constructed to overcome these empirical problems in specifying a set of normative reference values for the Songkhla/Hat Yai area. Although the values within these visions on CTVs are not clearly specified, they are useful in the evaluation of the effects of the development scenarios on the sustainability indicators. These auxiliary visions are coined here: weak, moderate and strong progress.

In the impact matrix, the effects on the sustainability indicators are represented by standardised qualitative values originating from the impact matrix; these values can also be used to develop different CTVs for each sustainability indicator.

Within the 'weak progress' vision, CTVs are set less stringently than in other visions on CTVs. Sustainability in this vision is defined as 'non-negative' impacts on the sustainability indicators, and sustainability is thus achieved when the effects of a development scenarios has at least a +/- sign, (i.e. no further environmental decay). So, this vision contains the minimum CTVs for the sustainability indicators.

Within the two visions (moderate and strong progress) the CTVs become more stringent; this is useful in order to identify the most sustainable development scenario. If, for example, scenario A is sustainable within the 'strong progress vision', and if the other two scenarios's (B and C) meet only the requirements for sustainability within the 'weak progress vision', one may conclude that scenario A is the most sustainable one. For each sustainability indicator the

relevant CTV is represented in a qualitative sense, and will receive the values shown in Table 1. In Section 5 the results of the sustainability assessment are given, while also the results of the comparison of the effects with the visions on the CTVs will be analysed for all sustainability indicators.

Step 4: evaluation of sustainability strategies or scenarios

In the sustainability assessment the outcomes of sustainability indicators are compared with the CTVs by means of the Flag Model. After the comparison of a sustainability indicator with its CTV, a coloured flag is assigned to (the value of) this indicator. The set of sustainability indicators is evaluated in a separate model of the Flag software programme. Due to lack of quantitative information, a qualitative approach is necessarily used here. The qualitative approach only takes into account the colour of the flags. Only flag counts and cross-tabulation are allowed. The outcomes can also be visualised by means of pie charts and stack bars. The results of the comparison will be presented in Section 5.

4.4 General specification of scenario effects

Decentralisation Scenario

The decentralisation scenario has a slightly to substantially positive influence on employment, total income and income distribution. Slightly positive effects on the social indicators may also be distinguished. These effects were to be expected, because this scenario was developed to redistribute welfare from Bangkok to the regional centers and the surrounding areas. In this respect this scenario seems successful. But it also has a shadow-side, as it is accompanied by undesirable environmental effects, which take up an extra amount of renewable and exhaustible resources.

The assimilative capacity of the environment is also negatively affected. These combined effects may nevertheless slightly improve regional welfare. The extent to which this scenario meets the pre-defined CTVs, and hence to which extent it meets the conditions for sustainability, is discussed in Section 6.

Promotion of sectoral and regional development scenario

This scenario has also a positive influence on employment, total income and the income distribution. The effects on total income are less substantial, probably because of the measures concerning the IMT-growth triangle.

These initiatives will mainly have positive effects in the long term; in the first instance, they will be focused on the primary sector, which was already under some pressure in Thailand. The effects on the social indicators are approximately the same as the effects on the social indicators in the former scenario. Decentralisation however, has a broader effect on the supply of housing. This seems a logical consequence, since this scenario focuses on the decentralisation of income and prosperity. On the other hand, the promotion of sectoral development has a less negative impact on the environment. This is mainly caused by measures which are focused on the restructuring of the agricultural sector and which emphasise improvements in cultivation systems and farming methods, the formulation of land

use policies in order to bring agricultural activities in line with the potential of the land, and the higher accessibility to water resources. Measures that concern the promotion of tourism also have a positive influence on the environment, especially with regard to natural environment conservation. The total effect on social welfare is likely not very different from the effect the decentralisation scenario has on this indicator.

Environmental protection scenario

The final scenario seeks to ensure an improvement of environmental quality in the area. With regard to this scenario it is plausible that it will have a positive effect on all environmental indicators, and this is indeed shown in the impact matrix. This scenario however, has only a very slightly positive influence on employment and the income distribution. An improvement in environmental protection results clearly in the improvement of the quality of life in the Songkhla/Hat Yai area.

5. Interpretation of the Results of the Thai Case Study; Application of the Flag Model

We will now concisely interpret the results of the three auxiliary visions for assessing tentative values for the CTVs, viz. the weak, moderate and strong progress vision, respectively. Here we will present in Figures 3-5 the results of the Flag Model in terms of the frequency of flags for each of the three scenarios and for the three distinct visions on CTVs.

5.1 Weak progress vision

It seems plausible that the environmental protection scenarios is the most sustainable one, based on the CTVs in the weak progress vision. The influence the environmental protection scenario has on the economic indicators is limited; it is, in fact, surprising that eight yellow flags are counted for these indicators. Thus, the environmental protection scenario is not in all cases very convincing.

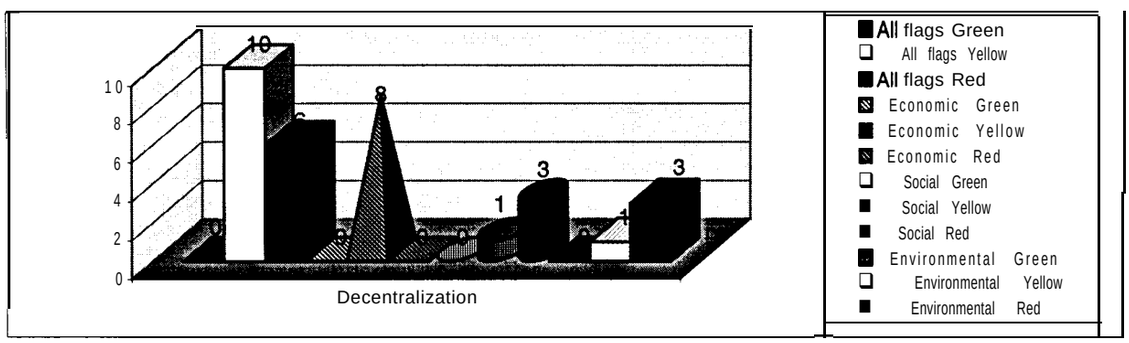


Figure 3A: Frequencies of flags for the Decentralization Scenario.

G= 'green' flag: no reason for specific concern; Y= 'yellow' flag: be alert; R= 'red' flag: reverse trends.

Clearly, the environmental protection scenario has more yellow flags counted for environmental indicators; this might, however, be expected.

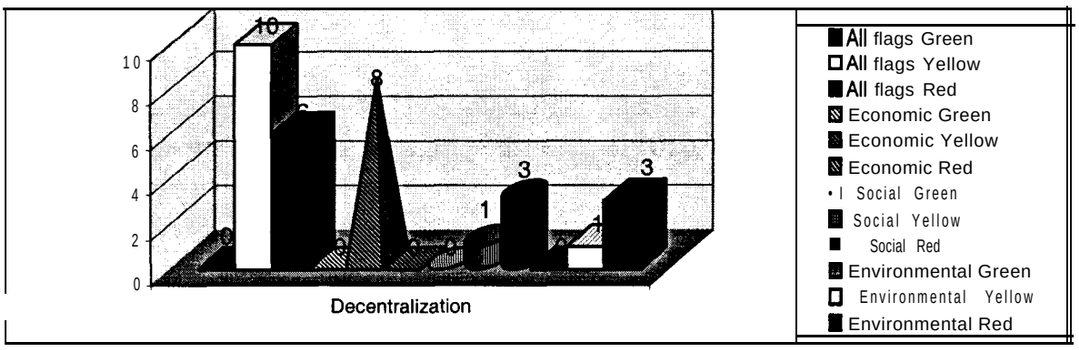


Figure 3B: Frequencies of flags for Regional and Sectoral Promotion.

We will now interpret some pairwise results of the scenario comparison. After comparing the decentralisation scenario with the sectoral and regional promotion scenario, we can see that both scenarios have identical scores on the sustainability indicators. There are no indicators for which the decentralisation scenario gives a better score than the sectoral and regional promotion scenario.

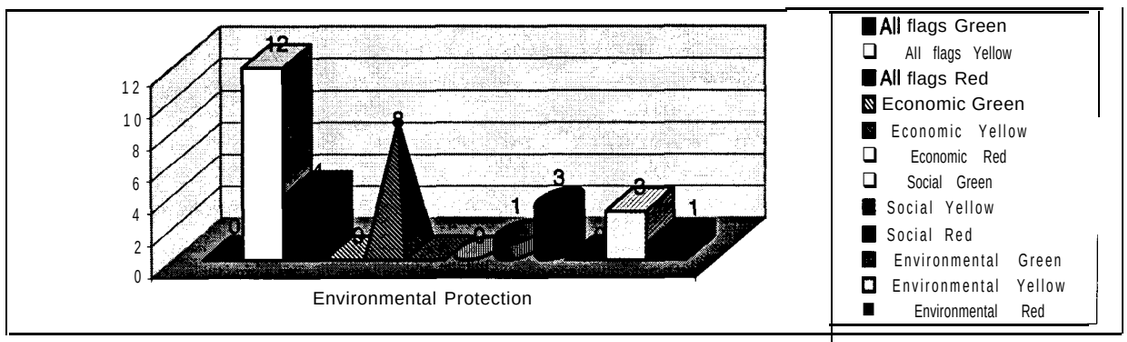


Figure 3C: Frequencies ofjlags for the Environmental protection scenario.

The results show that there are three indicators for which the environmental protection scenario gets a better score than the decentralisation scenario. The decentralisation scenario has only one indicator, for which the score is better than for the environmental protection scenario. We may thus conclude that, with the application of the weak progress vision, the environmental protection scenario is favoured over the decentralisation scenario.

There are three indicators for which the environmental protection scenario obtains a better score than the sectoral and regional promotion scenario. We may conclude that the environmental protection scenario is favoured over the sectoral and regional promotion scenario. After the comparison of the different development scenarios we can conclude that the environmental protection scenario is the most favoured scenario within the context of the weak progress vision on CTVs, followed by the decentralisation scenario and the sectoral and regional promotion scenario.

5.2 Moderate progress vision

Next, we will analyse the consequences of the moderate progress vision (Figures 4A-C). With the application of this vision on CTVs, the differences between the development scenarios

become more significant. The environmental protection scenario especially becomes less sustainable. Twelve red flags were counted for this scenario; most of them were assigned to the economic indicators. Relatively positive scores were found on the social and environmental indicators (three yellow flags in total). It seems that economic development is sacrificed in order to achieve ecological sustainability.

Although the decentralisation and sectoral and regional promotion scenario display a large number of red flags (8 and 7), they are more sustainable than the environmental protection scenario.

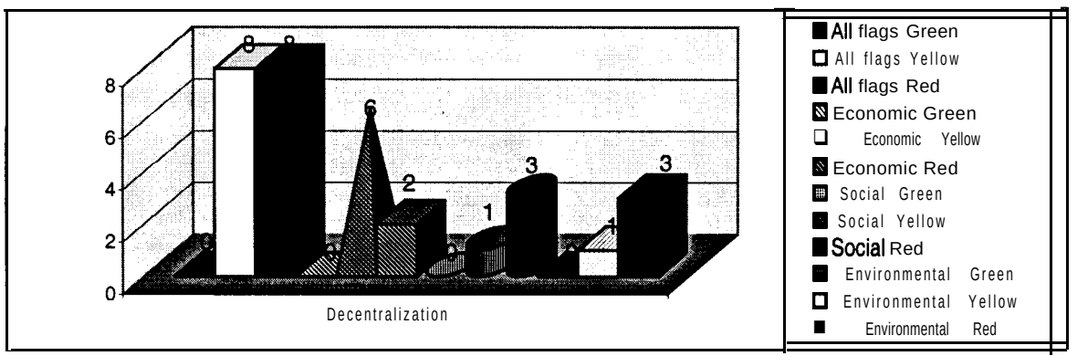


Figure 4A: Frequencies of flags for the Decentralization scenario.

The relative positive scores (yellow flags) are mainly seen for the economic indicators. The objectives of these scenarios, viz. redistribution of income and the strengthening of regional-economic sectors, seem to be well achieved with the use of the policy measures. But these scenarios compromise economic growth for social and environmental sustainability.

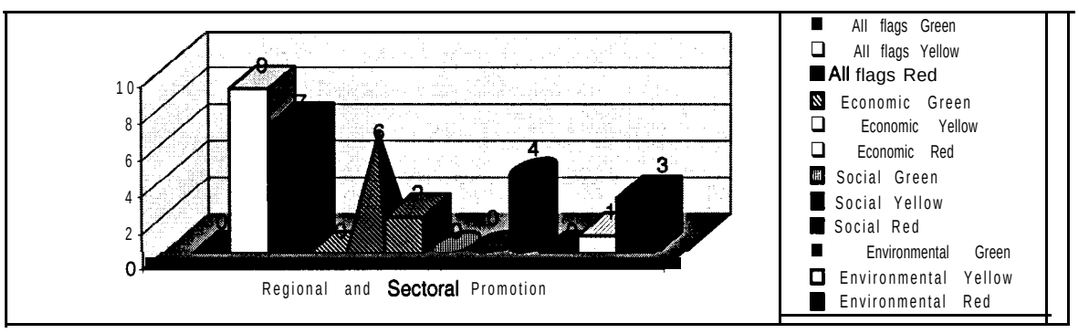


Figure 4B: Frequencies of flags for Regional and Sectoral Promotion.

The comparison of the decentralisation scenario with the sectoral and regional promotion scenario makes clear that the decentralisation scenario is slightly more sustainable than the sectoral and regional promotion scenario.

There are two indicators for which the decentralisation scenario obtains a better score than the sectoral and regional promotion scenario. The sectoral and regional promotion scenario scores on one indicator better than the decentralisation scenario.

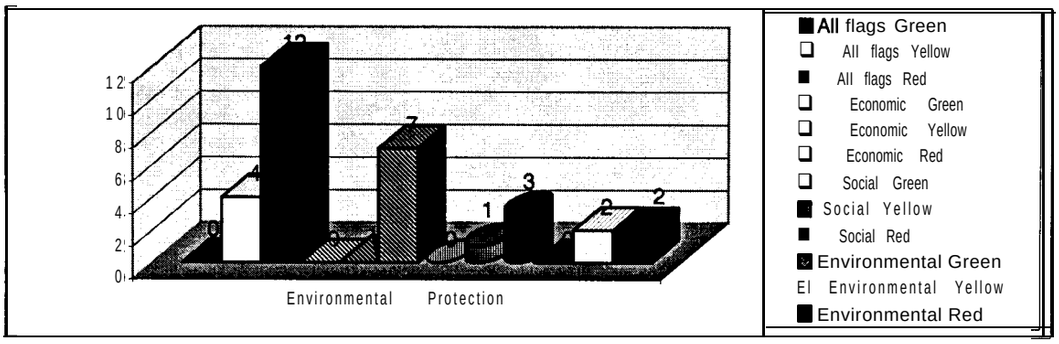


Figure 4C: Frequencies of flags for the Environmental Protection scenario.

There are six indicators for which the decentralisation scenario obtains a better score than the environmental protection scenario. The environmental protection scenario has two indicators for which the score is better than for the decentralisation scenario. We can thus conclude that the decentralisation scenario is more favoured than the environmental protection scenario.

There are also seven indicators for which the sectoral and regional promotion scenario obtains a better score than the environmental protection scenario, while there are four indicators for which the environmental protection scenario obtains better results than the sectoral and regional promotion scenario. We may thus conclude that the sectoral and regional promotion scenario is favoured over the environmental protection scenario.

The conclusion is that with the application of the moderate progress vision on CTVs, the decentralisation scenario is the most favourable scenario, followed by the sectoral and regional promotion.

5.3 Strong progress vision

Finally, we will analyse the results of the strong progress vision on CTVs. Under these conditions, none of the scenarios can meet the sustainability conditions in all respects. Although the decentralisation scenario and sectoral and regional promotion scenario have some yellow flag scores for the economic indicators, reverse trends occur for the social and environmental indicators. The environmental protection scenario is unsustainable with respect to all indicators (economic, social and environmental).

The cross tabulation of flag counts shows no differences in sustainability between the decentralisation scenario and sectoral and regional promotion scenario. Both scenarios have the same scores on the sustainability indicators.

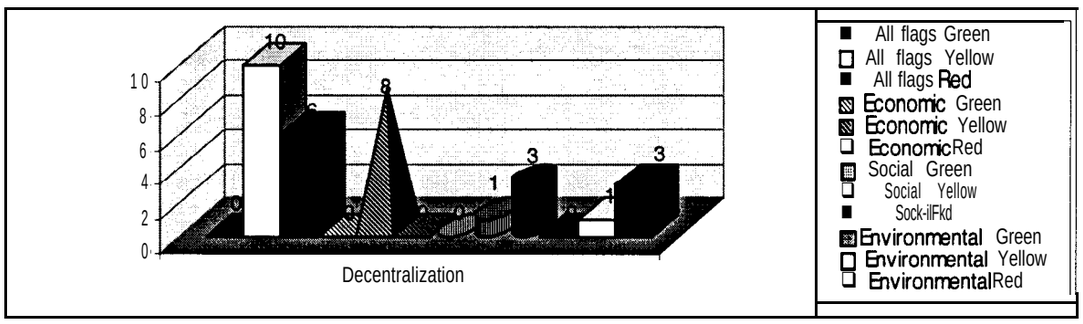


Figure 5A: Frequencies of flags for the Decentralization scenario.

The environmental protection has the highest number of negative scores on many scores on the indicators. This is caused by the severe negative effects on the economic indicators, such as total income, income distribution and employment. The other two scenarios show some 'yellow' scores on these indicators and therefore their overall sustainability is slightly better. All three scenarios have the same negative effects on the environmental indicators.

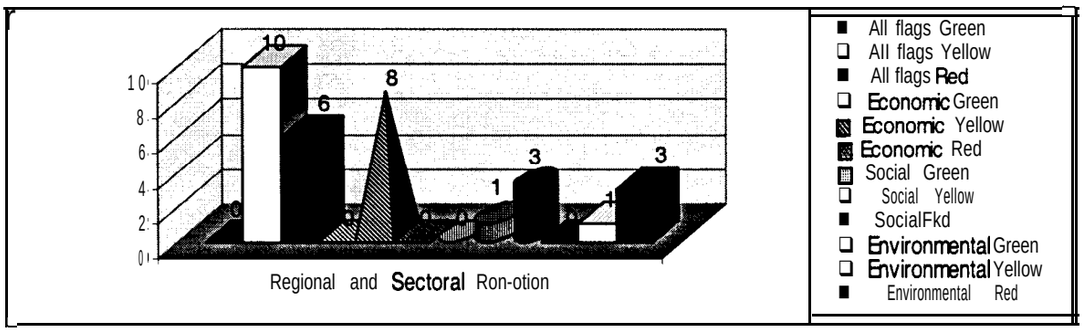


Figure 5B: Frequencies of flags for the Decentralization scenario.

In conclusion, the assessment of sustainability of the Songkhla/Hat Yai area shows that sustainability is only achieved at the lowest defined levels of the CTVs ('weak progress development'). If CTVs are set more stringently, none of the development scenarios is able to achieve sustainability scores on the social and environmental indicators.

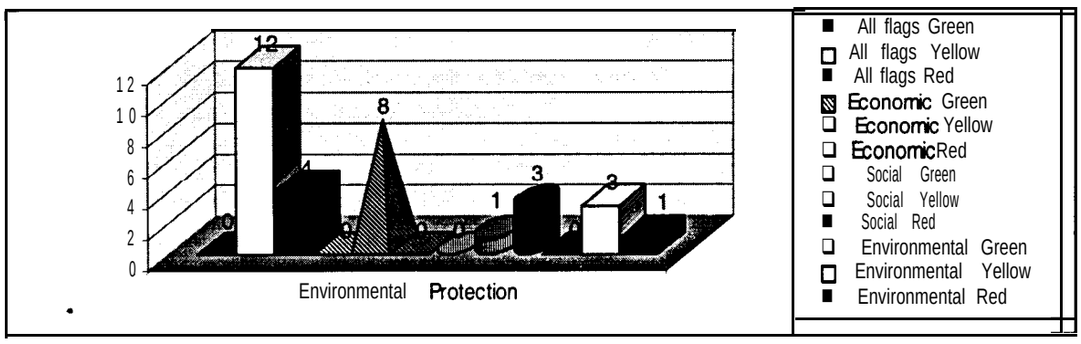


Figure 5C: Frequencies of flags for the Environmental Protection scenario.

The decentralisation and sectoral promotion scenarios show some relatively positive scores on the economic indicators. The influence of the environmental protection scenario on the

economic indicators is neither positive nor negative, and therefore this scenario becomes less sustainable when strict CTVs are applied. It may be concluded that the decentralisation scenarios is the most favourable development scenario; this scenario is followed by the sectoral and regional promotion scenario. According to our assessment the environmental protection scenario is the least favourable scenario, mainly because its positive effect on the economic indicators is marginal.

6. Regime Analysis for Obtaining a Rank Order of Alternatives

The Regime Method described in Section 3.2 allows us to analyse an impact matrix containing (mixed) data and a weight vector in order to calculate a rank order of alternatives. The weights are assumed to be equal here, but alternative weight compositions can be handled by means of a sensitivity analysis.

The software used to evaluate all alternatives in this case study (SAMIsoft) translates all scores as benefit criteria; this means that the higher an alternative scores on a criterion the better it is.

In our case study research, the Regime Analysis was conducted on the results of the Flag Model. As indicators we used the flag colours (Green, Yellow, Red and Black) and the number of flags counted for the various flag colours. Therefore, the results in Figures 3, 4 and 5 form the input for our Regime Analysis. Since Regime Analysis assigns a positive judgement to high scores on indicators, we have to be careful to apply this method on the results of the Flag Model straightforward. For example, a high number of red flags will be positively judged by the Regime method, while from a sustainability perspective reverse trends occur. As a consequence, we consider the Green and Yellow flag scores as benefit indicators and the Red and Black flag scores as cost indicators and were transformed them into benefit indicators. Table 3 shows these standardised indicator scores per vision on the CTVs. The results of the Regime Analysis per CTV vision are presented in Table 4. It is no surprise that the results do not differ from the results of the Flag Model.

Table 3. Standardised Impact Scores per CTV vision.

	Weak Progress			Mode ate Progress			Strong Progress		
	G	Y	R	G	Y	R	G	Y	R
Decentralization	0	10	0.7	0	8	1	0	3	1
Regional and Sectoral Promotion	0	10	0.7	0	7	0.89	0	3	1
Environmental Protection	0	12	1	0	4	0.67	0	0	0.81

Table 4. Rank order of alternatives.

	Prob			***Rank***		
	Weak	Moderate	Strong	Weak	Moderate	Strong
Decentralization	***0.25***	1	***0.75***	***2***	1	1
Sectoral and regional promotion	***0.25***	***0.5***	***0.75***	***2***	***2***	1
Environmental protection	1	0	0	1	***3***	***3***

7. Summary and conclusion

The aim of this study was to analyse various development scenarios in relationship to the spatial economic development of the Thai city of Songkhla and its adjacent areas. The main focus was on the assessment of sustainable development of this area. The strategic policy findings are briefly summarised here.

The decentralisation scenario

The decentralisation scenario has a slightly to substantially positive influence on employment, total income and income distribution. Slightly positive effects on the social indicators can also be traced. These effects were to be expected, because this scenario was developed to redistribute welfare from Bangkok to the regional centers and surrounding areas. The scenario also has a shadow side, as undesirable environmental effects as a result of the use of additional renewable and exhaustible resources accompany it. The assimilative capacity of the environment is also negatively affected. These combined effects therefore, result only in a slight improvement in the total effect on the welfare function of the region under investigation.

The scenario on the promotion of sectoral and regional development

This scenario also has a positive influence on employment, total income and income distribution. The effects on the social indicators are approximately the same as the effects on the social indicators in the former scenario. This scenario, however, has a less negative effect on the environment. This is mainly caused by measures that are focused on the restructuring of the agricultural sector. The total effect on social welfare in the area is not significantly different from the effect the decentralisation scenario has on this indicator.

The environmental protection scenario

In regard to this scenario it was expected that it would have a positive effect on the environmental indicators, and the impact matrix correctly shows this. This scenario, however, has only a very slightly positive influence on employment and income distribution. An improvement of the environment clearly results in the improvement of the quality of life in the Songkhla/Hat Yai area, but to the detriment of economic growth.

Our assessment of sustainability of the Thai region under consideration shows that sustainability is only achieved at the lowest defined levels of the CTVs ('weak progress'). If the CTVs are set more stringently, none of the development scenarios is able to achieve

sustainability in terms of social and environmental indicators. The decentralisation and sectoral and regional promotion scenarios show some relatively positive scores on the economic indicators. The influence of the environmental protection scenario on the economic indicators is neither clearly positive nor negative, and therefore this scenario becomes less sustainable when strict CTVs are applied. It can thus be concluded that the decentralisation scenario is the most favourable development scenario, followed by sectoral and regional promotion. In our assessment approach the environmental protection scenario is the least favourable scenario because, its positive effect on relevant economic indicators is almost negligible.

Finally, it is important to critically judge the methodological tools employed in our sustainability analysis. There are three critical points that deserve our attention. Firstly, the development of a complex regional system model is of critical importance, even though often by necessity a qualitative assessment has to take place. Secondly, the use of CTVs appears to offer an operational framework for sustainability analysis at the regional level, although lack of quantitative and reliable information may force researchers to resort to adjusted qualitative methods (e.g. the auxiliary visions introduced by us). And finally, the flag approach, combined with Regime Analysis, has demonstrated its feasibility, even in cases like ours where no unambiguous expert information was available.

References

Abel, N., Mis-measurement of the Productivity and Sustainability of African Communal Rangelands: a case study and some principles from Botswana, Ecological Economics, vol.23, no.2, 1997, pp. 113-133.

Banister, D., Urban Sustainability, in Bergh J.C.J.M. van den (ed.), Handbook of Environmental Resource Economics, Edward Elgar, Cheltenham, 1999, pp. 560-569.

Beinat, E., Value Functions for Environmental Management, Kluwer, Dordrecht, 1997.

Bergh, J.C.J.M. van den, Ecological Economics and Sustainable Development, Edward Elgar, Cheltenham, UK, 1996.

Bithas, K., Nijkamp, P., and A. Tassopoulos, Environmental Impact Assessment by Experts in Cases of Factual Uncertainty, Project Appraisal, vol. 12, no.2, 1997, pp. 70-77.

Capello, R.P, Nijkamp, P., Pepping, G., Urban Sustainabilitv and Energy Policies, Springer-Verlag, Berlin, 1999.

Ciriacy-Wantrup, , S.V., Resource Conservation, Economics and Policies, University of California Press, Berkeley and Los Angeles, 1952.

Douven, W.J.A.M., Improving the accessibility of snatial information for environmental management: an application to pesticide risk management, Ph.D. Dissertation, Free University Amsterdam.

Finco, A., and P. Nijkamp, Towards a Sustainable Future of Cities in Europe: an Evaluation of Sustainable City Initiatives Using Multicriteria Decision Support Methods, in Stillwell, J.C.H. and H.J. Scholten (eds.), Land Use Simulation for Europe, Kluwer, Dordrecht, 2001, pp. 23-38.

Giaoutzi, M., and P. Nijkamp, Decision Support Models for Regional Sustainable Development, Avebury, Aldershot, UK, 1993.

Knut, H.A., Torstein, B., Solveig, G., and H. Wiig., Soil Degradation and Economic Development in Ghana, Environment and Development Economics, vol.2, no.2, 1997, pp. 119-143.

Lichfield, N., P. Vettle and M. Whitbread, Evaluation in the Planning Process, Pergamon Press, London, 1975.

Lichfield, N., Community Impact Evaluation, University College Press, London, 1996.
Munda, G., Fuzzv Information in Multicriteria Environmental Evaluation Models, Physika-Verlag, Heidelberg, 1995.

Nijkamp, P., Environment and Regional Economics, Handbook Environmental Economics (J.C.J.M. van den Bergh, ed.), Edward Elgar, Cheltenham, UK, 1999.

Nijkamp, P. and H. Ouwersloot, A Decision Support System for Regional Sustainable Development: The Flag Model, Theory and Implementation of Sustainable Development Modeling (J.C.J.M. van den Bergh and M.W. Hofkes, eds.), Kluwer, Dordrecht, 1998, pp. 255-273.

Nijkamp, P. & R. Vreeker, Sustainability Assessment of Development Scenarios: methodology and application to Thailand, Ecological Economics, Elsevier, 2000.

Pelt, M.J.F. van, Ecological Sustainability and Sustainable Development, Avebury, Aldershot, UK, 1993.

Pelt, M.J.F. van, A. Kuyvenhoven and P. Nijkamp, Environmental Sustainability: Issues of Definition and Measurement, International Journal of Environment and Pollution, vol.5, no.2/3, 1994, pag. 204-223.

Pelt, M.J.F. van, A. Kuyvenhoven and P. Nijkamp, Defining and Measuring Sustainability, Research Memorandaurn, Free University, Amsterdam, 1992.

Pezzey, J., Economic Analysis of Sustainable Growth and Sustainable Development, The World Bank, Washington D.C., 1989.

RMNO, Het Begrip Duurzaamheid, 1994, Rijswijk.

Sami, SAMIsoft, Deliverable 5, Submitted to EU-DG VII, Strategic Research, Brussels, Belgium, 2000.

Wackemagel, M., Rees, W., Our Ecological Footprint: Reducing Human Impact on the Earth, The New Catalist Bioregional Series, vol. 9., 1996, New Society Publishers, Gabriola Island, BC and Philadelphia.

Weterings, R.A.P.M, and J.B. Opschoor, Environmental Utilisation Space and Reference Values for Performance Evaluation, Milieu, vol.9, no.4, 1994, pp. 22 l-228.

Annex 1. Concise description of policy scenarios

Table 1. A. Decentralization Scenario

Objectives:	Measures:
• Redistribution of income and development benefits to the regions and rural areas in order to reduce income disparities;	• Implementation of monetary, fiscal and capital market development policies; • Implementation of fiscal and public expenditure policies; • Decentralization of fiscal and budgetary power to the provinces and local authorities;
• Dispersion of property ownership to enable those involved in agriculture to have legal ownership of land or securities in farmland;	• Land reform programs, issuance of land titles, housing credit provision for low-income groups;
• Enable people to have their own dwellings, or to have security in rental agreements;	• Promulgation of the Slum Improvement Act;
• Development of regional centers to serve as an economic and employment base in a region, in order to take advantage of the decentralization of economic activities;	• Development of regional centers, to be accomplished by creating basic infrastructural networks in and around these regional centers; • The dispersion of growth to towns surrounding this centers by linking those towns to the basic infrastructure networks in and around the regional centers;
• Upgrading the quality of life of rural people;	• Decentralization of authority, procedures and budgets;
• Upgrading the quality of life of the urban poor;	• Policies to emphasize income increase, ugrading of housing, provision of welfare and basic social services;
• The provision of infrastructural services in order to meet the demand for infrastructural services.	• Infrastructural investments in regions (communication services and transportation); • Development of infrastructural networks in regional cities; • Construction of ring roads and bypasses, and improvements in the efficiency of urban and inner-city systems.

Table 2. B. Promotion of Sectoral and Regional Development Scenario

B. 1 Industries and services (including tourism)

Objectives:	Measures:
Restructuring regional economies into more industrial and service based economies, instead of agricultural base economies;	• Dispersion of industries and services to regions by strengthening regions with a strong potential to serve as regional centers in the development of industries; • Industrial development in the new economic zones such as the Southern Seaboard; • Acceleration of industrial decentralization to regional urban centers; • Investments in industrial real estate to meet industrial requirements and demand;
Promotion of agro-industry within the area (rubber, palm oil and sea food processing);	• Support of agro-industries by setting up agricultural production zones to provide raw materials for the agro-industry;
The Songkhla/Hat Yai area should serve as one of the nine industrial centers in Thailand; the Southern Seaboard should serve as a long-term economic base within Thailand;	• Dispersion of social infrastructural services to the region, especially educational services; • Industrial cites should be set up in the region; • Investments in labour training; • Supporting local entrepreneurs to enhance their managerial efficiency and their use of technology; • Industrial credit will be granted on a wider basis; • Establishment of small and medium-size industrial zones in inland areas which have a high industrial potential;
• A more competitive internal market environment;	• Reducing protection of domestic industries;
• Influx of more high-tech industries in the area;	• Supporting oil-refining, petrochemical/ petroleum industries and related industries, by investments in infrastructure;
• Songkhla/Hat Yai should be the center of tourism in the lower South.	• Encouragement of the private sector to invest in new tourism activities; • Environmental conservation; • Investments in infrastructure; • Investments in training and quality of personnel.

B.2 Agriculture

Objectives:	Measures:
• Rise in agricultural incomes;	• Agricultural restructuring;
• Increase in agricultural productivity;	• Improvements in cultivation systems and farming methods;
• Protection of agricultural workers to ensure their income;	• Formulation of land use policies to get agricultural activities in line with the potential of the land;
• Maintenance of stable commodity prices;	• Policies should encourage the private sector to invest in research and development activities;
• Agriculture and agro-industries should play a more important role in Gross Domestic Product;	• Investment in basic services to support the transition in the production structure of Thai farmers;
• Agricultural land use patterns should be more diversified.	• Establishment of agricultural markets in regional urban centers.

B3. IMT-triangle

Objectives:	Measures:
• Southern Thailand (Songkhla/Hat Yai) should function as a gateway for trade with neighbouring countries;	• Investments in infrastructural networks (communication and transportation networks);
• Songkhla/Hat Yai will be the center of trade and services in the lower South of Thailand;	• Investments in road networks, Songkhla Seaport and Hat Yai airport to strengthen the position of the Twin Cities in Southeast Asia;
• The Southern Seaboard will be developed as an 'economic bridge' linking the Andaman Sea with the Gulf of Thailand.	• Linking Songkhla and Hat Yai with other border trade points, by investments in infrastructure.
• The Southern Seaboard will be developed as an 'economic bridge' linking the Andaman Sea with the Gulf of Thailand.	• Linking Songkhla and Hat Yai with other border trade points, by investments in infrastructure.

Table 3. C. Environmental Protection Scenario

Objectives:	Measures:
• Conservation and rehabilitation of natural resources;	• Establishment of environmental administrations; • Preservation of historical sites;
• Together with the development of infrastructure within the region, there will be also a careful environmental monitoring;	• Increase of managerial efficiency to reduce losses in resources (water and electricity transmissions);
• Relieve congestion in rapidly expanding urban areas;	• Improvements in town planning; • Investments in public transport systems to solve congestion problems in urban business districts;
• More control over areas facing critical environmental problems (local authorities);	• Investments in waste water treatment systems; • Local authorities will be encouraged to improve their land use planning and accelerate the formulation of plans to preserve historical sites and recreational areas; • Specific zones will be demarcated for pollution generation industries in order to facilitate more control over pollution, as well as to economize on the costs of pollution control;
• Enforcement of the polluter-pays principle.	• Internalization of environmental costs in commodity prices.